JAN JOURNAL OF ADVANCED NURSING

ORIGINAL RESEARCH

Pressure ulcer development in older residents in nursing homes: influencing factors

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Accepted for publication 19 June 2009

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KWONG E.W.-Y., PANG S.M.-C., ABOO G.H. & LAW S.S.-M. (2009) Pressure ulcer development in older residents in nursing homes: influencing factors. *Journal of Advanced Nursing* **65**(12), 2608–2620.
doi: 10.1111/j.1365-2648.2009.05117.x

Abstract

Title. Pressure ulcer development in older residents in nursing homes: influencing factors.

Aim. This paper is a report of a study assessing pressure ulcer incidence and factors affecting pressure ulcer development among older nursing home residents.

Background. Previous researchers have shown that demographic, clinical, health status, risk and human resources factors affect pressure ulcer development among older people in various healthcare settings, but none has investigated their interactive effects among older nursing home residents.

Method. This was a prospective cohort study involving 346 residents aged 65 years or over from four private nursing homes in Hong Kong. We collected information on participant demographics and assessed their clinical characteristics, health status and pressure ulcer risk factors. Subsequently, we assessed their skin condition every 2 days for 4 weeks to detect pressure ulcers that developed after the initial assessment. The data were collected between December 2006 and September 2007.

Results. The pressure ulcer incidence was 25·16%. The model in which the factors of clinical characteristics, health status, pressure ulcer risk and human resources were controlled was more reliable in predicting pressure ulcer development than the other two models. It showed that bedfast or chairfast residents, especially those with co-morbidities (renal failure and stroke) and living in nursing homes where there were no nurses but more nursing assistants, were at higher risk for pressure ulcer development.

Conclusion. Evidence-based interventions should be adopted to minimize the possible problems of pressure, malnutrition, friction and shear force, and the decreased pain perception of bedfast or chairfast residents in nursing homes, especially those with renal failure or stroke.

Keywords: long-term care, nursing homes, older people, pressure ulcers

Introduction

Pressure ulcers are a serious health problem that causes pain, slow recovery from morbid conditions, infection and death (Graves *et al.* 2005, Landi *et al.* 2007). They increase healthcare resource use, length of hospital stay, treatment costs and nursing time (Whittington & Briones 2004, Fogerty *et al.* 2008). Although they occur in patients of all ages, older people are at high risk of developing pressure ulcers, as reflected in the fact that 70–73% of those who develop pressure ulcers are over 65 years old (Whittington *et al.* 2000, Thomas 2006). Previous studies have shown a pressure ulcer incidence of 6·2% and 8·8% in hospitalized older patients (Baumgarten *et al.* 2003, 2006) and 1·61% for older patients in an outpatient setting (Margous *et al.* 2003). Comparatively higher pressure ulcer incidences of 11·9% (Vap & Dunaye 2000), 23·2% (Baumgarten *et al.* 2004) and 39·4% (Santos & Souza 2007) have been observed in older people in nursing homes. In the absence of an adequate supply of community support services, frail community-dwelling older people are placed in nursing homes for long-term care, and so their residents are on average more impaired and dependent than those living in other settings; this may result in a higher risk for pressure ulcers.

Fortunately, almost 90% of pressure ulcers can be prevented (Gunningberg *et al.* 1999) by accurate prediction and appropriate nursing interventions to reduce and/or eliminate factors associated with pressure ulcer development. Thus, identifying factors associated with pressure ulcer development is the first step in prevention for nursing home residents. Research has identified demographic, clinical, health status, risk and human resources factors in various healthcare settings, but to our knowledge none has included these factors to test how they interactively influence pressure ulcer development among older residents in nursing homes.

Background

Demographic factors

Patients older than 85 years assessed in general medical practice (Margolis *et al.* 2002) and nursing home residents who are 70 years of age or older are particularly susceptible to developing pressure ulcers (Dellefield 2004). Older males residing in long-term care facilities (Okuwa *et al.* 2006) and hospitals (Baumgarten *et al.* 2006) are more likely to develop pressure ulcers than their female counterparts, contrary to Santos and Souza's (2007) report that female gender is a predictor of pressure ulcer development.

Clinical factors

The consumption of sedatives increases the likelihood of pressure ulcer development in hospitalized older patients (Lindquist *et al.* 2003). However, adults in long-term care facilities who receive nasogastric tube feeding for more than 21 days and take antidepressants are less likely to develop pressure ulcers than those not receiving nasogastric tube feeding and not taking antidepressants (Horn *et al.* 2004).

Health status factors

Activities of daily living, cognitive function, disease-induced impairment and comorbidities are important aspects in older people's health. Poor ability in activities of daily living, severe illness, severe disability, cognitive impairment, confusion and poor mental status are predictors of pressure ulcers in long-term care facilities (Horn *et al.* 2004, Capon *et al.* 2007), hospitals (Reed *et al.* 2003, Mecocci *et al.* 2005, Soderqvist *et al.* 2007) and nursing homes (Van Marum *et al.* 2000). Cardiovascular diseases are predictive of pressure ulcers in long-term units (Capon *et al.* 2007). Alzheimer disease, chronic obstructive pulmonary disease, stroke, diabetes mellitus, Parkinson disease, heart failure and rheumatoid arthritis have effects on pressure ulcer development, but angina, hypertension and pneumonia were inversely associated with pressure ulcer development among older patients in study conducted in an outpatient setting (Margous *et al.* 2003).

Pressure ulcer risk factors

Pressure ulcer risk prediction scales quantify known risk factors. The Braden (Bergstrom *et al.* 1987), Norton (Norton *et al.* 1975) and Waterlow (1985) are commonly used risk scales to predict pressure ulcer development. Empirical data have suggested that the Braden Scale is the most effective of the three scales (Pancorbo-Hidalgo *et al.* 2006, Kring 2007). The Braden Scale (Bergstrom *et al.* 1987) was derived from Braden and Bergstrom's (1987) conceptual schema, which stated that the intensity and duration of pressure and skin tolerance (tissue tolerance) are the critical determinants in the formation of pressure ulcers. It includes six risk factors: mobility, activity, sensory perception, skin moisture, nutritional status and friction or shear. Previous studies have shown that poor mobility (Papanikolaou *et al.* 2002, Bergquist 2003), long periods of being bedfast (Okuwa *et al.* 2006), impaired self-positioning in bed (Mino *et al.* 2001), difficulty turning in bed (Baumgarten *et al.* 2006), decreased pain perception (Ash 2002), friction or shear, dry skin, urinary and faecal incontinence (Bergquist 2001, 2003,

Papanikolaou *et al.* 2002, Baumgarten *et al.* 2006), moisture (Bergquist 2001), eating problems (Horn *et al.* 2004), poor appetite (Papanikolaou *et al.* 2002), poor nutritional status (Reed *et al.* 2003), Low Ankle-Brachial Index value (Okuwa *et al.* 2006) and low albumin level (Mino *et al.* 2001, Reed *et al.* 2003) are risk factors in pressure ulcer development among older people receiving home health care and adult patients living in long-term care facilities and hospitals. Kwong *et al.* (2005) developed the Modified Braden Scale (MBS) by adding skin type and body build for height and excluding nutrition from the Braden Scale. This modified version was found to be more predictive of pressure ulcer development in hospitalized adult patients than the complete Braden Scale (Xue *et al.* 2004, Kwong *et al.* 2005, Chan *et al.* 2009). A study suggested that sensory perception, skin type and body build for height were the predictors of pressure ulcer development in orthopedic adult patients (Chan *et al.* 2009). In view of the better predictive power of the Braden and MBS, the risk factors in the two scales are considered as common pressure ulcer risk factors and were investigated in the study reported in this paper.

Human resource factors

More than 15 minutes per resident/day and certified nursing assistant time of more than 2 hours per resident/day (Horn *et al.* 2004) and nurses and auxiliary staff at or more than five per 10 beds (Capon *et al.* 2007) decrease the likelihood of people developing pressure ulcers in long-term care facilities. More direct care time by Registered Nurses, certified nursing assistants and Licensed Practical Nurses per resident per day have been statistically associated with lower rates of pressure ulcer development in long-stay nursing homes (Horn *et al.* 2005).

Summary

In summary, among the studies reviewed above, two studies included different combinations of the above factors for identifying factors associated with pressure ulcer development. However, Horn *et al.*'s (2004) investigation was a retrospective case–control study, while Capon *et al.* (2007) examined the factors associated with pressure ulcer prevalence in a cross-sectional study in which temporal relationships were not allowed. No studies have been conducted to investigate prospectively and longitudinally the interactive effects of demographics, clinical characteristics, health status, pressure ulcer risk factors and human resources factors on pressure ulcer incidence among older nursing home residents.

The study

Aim

The aim of the study was to identify pressure ulcer incidence and factors associated with pressure ulcer development among older residents in nursing homes. The specific objectives were to:

- Identify pressure ulcer incidence.
- Examine associations between demographics (age and gender), clinical characteristics (smoking, mode of feeding, use of sedatives or tranquilizers), health status (severity of impairment, comorbidities, activities of daily living and cognitive function), pressure ulcer risk (sensory perception, skin moisture, mobility, activity, friction and shear, skin type, body build for height, and nutrition) and human resources (availability of nurses working in homes, number of full-time nursing assistants per 100 residents) with pressure ulcer development.
- Identify factors affecting pressure ulcer development.

Design

A prospective cohort design was used. The data were collected between December 2006 and September 2007.

Participants

Residents from four private for-profit nursing homes located in the Eastern district of Hong Kong Island were the study participants. The size of the four homes ranged from 88 to 193 beds. None used pressure ulcer prediction scales or pressure ulcer prevention protocols. Two of the nursing homes employed nurses; all other staff were assistive personnel. The selection criteria for participants were being aged 65 years or over, present in the nursing homes on the days of data collection and willingness to participate in the study. Of all 504 residents in the four nursing homes, 22 (4·37%) were aged under 65 years, 47 (9·33%) declined to participate in the study, and 89 (17·66%) were not present in the homes because of hospitalization (n = 36) or going out (n = 53). There were no internal drop-outs. A total of 346 (68·65%) residents who met the selection criteria successfully participated in the study. With the sample size of 346, the study had a statistical power of 0·87 at a 0·05 level of statistical significance (nQuery Advisor R4 2001).

Instruments

Demographic and clinical data collection form

This form, designed by our research team, was used to record participant demographics and clinical characteristics.

Health status form

This form contained the Chinese versions of the Cumulative Illness Rating Scale (CIRS), Personal Activities of Daily Living (P-ADL) and Bedford Alzheimer Nursing Severity Subscale (BANS-S).

The CIRS (Linn *et al.* 1968), with good reliability (Miller *et al.* 1992, Parmelee *et al.* 1995), quantifies the severity of impairments induced by general medical problems and dysfunctions in six bodily systems: cardio-respiratory, gastrointestinal, genitourinary, musculoskeletal, psycho-neurological and endocrine. The Chinese version of the content-validated CIRS (Chan & Pang 2007), which added some common health problems among older people, for example constipation and cataracts, to the original CIRS Scale (Linn *et al.* 1968), assessed comorbidities and severity of impairment. Its response options range from 0 (no impairment) to 4 (life-threatening condition). The higher summative scores indicate more severe impairments.

The Chinese version of the P-ADL Scale (Chi & Leung 1995), with a Cronbach's alpha of 0·92 (Chan & Pang 2007), was used to assess performance in less complex self-care activities. It contains eight items of activities with options ranging from 1 (totally limited) to 3 (unlimited). Total scores range from 8 to 24. The higher the summative scores, the less the limitation in performing self-care activities (Lawton & Brody 1969).

The BANS-S, with good reliability (Volicer *et al.* 1993), was translated into Chinese and content-validated by Pang *et al.* (2005). The Chinese version of the 7-item BANS-S was used to assess cognitive function by evaluating their speech, eye contact, dressing, eating, ambulation, sleep-wake cycle disturbance and muscle rigidity. Its response options range from 1 (no impairment) to 4 (complete impairment) and its total scores are between 7 and 28. Higher summative scores indicate poorer cognitive function.

Pressure ulcer risk form

This form contained the Chinese version of the MBS (Pang & Wong 1998, Kwong *et al.* 2005) and the Braden subscale for nutrition (Bergstrom *et al.* 1987). It was used to assess common pressure ulcer risk factors: sensory perceptions, skin moisture, mobility, activity, friction and shear, skin type, body build for height, and nutrition. The Chinese version of the MBS includes the subscales of sensory perceptions, skin moisture, mobility, activity, friction and shear, skin type and body build for height. Each subscale is rated from 1 (least favourable) to 3 or 4 (most favourable). Summative scores range between 7 and 27. Higher scores indicate lower pressure ulcer risk. Cut-off points of 19 and 22 (sensitivity: 89%; specificity: 62–68%) have been identified among adult patients in acute-care settings (Xue *et al.* 2004, Kwong *et al.* 2005).

Skin assessment chart

This chart was used to record the numbers, sites and stages of pressure ulcers detected. We modified it from the 'Prevention & Care of Pressure Ulcer Record (Adult)' designed at Pamela Youde Nethersole Eastern Hospital (2006). In the chart, the common pressure ulcer sites, for example coccyx and ischial tuberosity, are numbered from 1 to 36 on a 'body map'. According to the National Pressure Ulcer Advisory Panel (2007), pressure ulcers can be staged from I to IV. A stage I ulcer is intact skin with non-blanchable redness of a localized area, usually over a bony prominence. Darkly pigmented skin may not have visible blanching and the area may be painful, firm, soft and warmer or cooler compared with the adjacent tissue. It is also considered reversible in that no irreparable tissue damage has occurred. A stage II ulcer is a partial thickness loss of dermis presenting as a shallow open ulcer with a red or pink wound bed, without slough. A stage III ulcer is full thickness skin loss. Subcutaneous fat may be visible but bone, tendon or muscle are not exposed, and slough may be present but does not obscure the depth of tissue loss; it may include undermining and tunnelling. A stage IV ulcer is full thickness skin loss with exposed bone, tendon or muscle; slough or eschar may be present on some parts of the wound bed, often including undermining and tunnelling. A pressure ulcer whose base is covered by slough or eschar in the wound bed is defined as 'unstageable'.

Human resources form

This form addressed the presence of nurses working in the nursing homes and the number of full-time nursing assistants and residents living in the homes.

Data collection

Data were collected using a questionnaire incorporating the above instruments. To collect the data concurrently in the four homes while avoiding operational difficulties and keeping the data collection period to a minimum, 3–4 research assistants with nursing backgrounds were assigned to each home. One week before the data collection, a research team member explained the data collection procedure and the questionnaire to all research assistants. According to the timeslots scheduled by an in-charge of each home, the research assistants visited the home and screened the residents for the study.

After obtaining oral informed consent from participants (or from the significant others of mentally impaired participants) who met the selection criteria, the research assistants performed an initial assessment of potential participants, covering demographics (gender and age), health status (cognitive function, activities of daily living, severity of impairment and comorbidities), clinical characteristics

(smoking, mode of feeding and use of sedatives) and pressure ulcer risk factors and skin condition to detect pressure ulcers.

After the initial assessment, two groups of participants with and without pressure ulcers were identified. Subsequently, the research assistants performed skin assessment every 2 days for 4 weeks with all participants to detect 'first' pressure ulcers in those without pressure ulcers in the initial assessment and 'new' pressure ulcers in those with pressure ulcers in the initial assessment. If pressure ulcers were detected, the research assistants recorded their location and staging and continued the assessments. The case was closed when the 4-week subsequent skin assessment was completed or the participant left the nursing home either temporarily (to be hospitalized) or permanently (death or transferal to other nursing homes).

From the officer in-charge of each nursing home, the research assistants collected data on the availability of nurses and the number of full-time nursing assistants working in the home and residents living in the home. During the data collection period, the research team member made several unannounced visits to each home to observe the research assistants in data collection and to check the forms to ascertain the accuracy of the data collected.

Validity and reliability

A panel of one gerontology experts and two wound care specialists validated the questionnaire, and reported a Content Validity Index of 1 after our two revisions. The Chinese versions of the CIRS, P-ADL and BANS-S demonstrated good internal consistency, as evidenced by high Cronbach's alpha coefficients (CIRS = 0·72, P-ADL = 0·95, BANS-S = 0·89). One week before the data collection, a wound care specialist refreshed the knowledge of all research assistants on the stages and location of pressure ulcers and then had them practise staging using pressure ulcer photos. Two days before the data collection, the wound care specialist and 15 research assistants independently assessed the pressure ulcers of 10 older hospitalized patients. In addition, a research team member and 15 research assistants independently assessed these 10 patients using the Chinese versions of the MBS, P-ADL and BANS-S. Cohen's multi-rater version of Kappa (staging = 0·84, location = 0·8) and intra-class correlation coefficients (MBS = 0·8, P-ADL = 0·9, BANS-S = 0·95) showed good inter-rater reliability (Landis & Koch 1977) with regard to the staging and location of pressure ulcers and the scales.

Ethical considerations

Ethics committee approval was obtained from the university, and the four nursing homes approved the study. Participants and the significant others of participants with mental impairment received an oral explanation of the study and possible risks. Oral consent was obtained, and they were assured that there would be no penalties if they refused any procedures and/or withdrew from the study at any time. Confidentiality was also assured.

Data analysis

The data were analysed using the Statistical Package for the Social Sciences – SPSS 15.0. Descriptive statistics was used to analyze participant characteristics and pressure ulcer incidence, stages and sites. Data from the human resources form was used to calculate the number of nursing assistants per 100 residents. As the skew values of the data were between 0·97 and −1·64 and the kurtosis values between 1·82 and −0·76, parametric tests could be used (Garson 2008). In the bivariate analysis to compare each factor and pressure ulcer development, the independent *t*-test was conducted for continuous and ordinal data and the chi-square test for nominal data. In the multivariate analysis, multiple logistic regression was used to analyse three models. The first included the statistically significant pressure ulcer risk factors in the bivariate analysis, while the second included all statistically significant factors except human resources factors in the bivariate analysis. The third model included all statistically significant factors in the bivariate analysis. Correlation coefficients among all factors in each model were low to moderate (at or below 0·63), except the value for activities of daily living and the activity subscale, which was 0·83. We therefore decided to exclude activities of daily living from the multivariate analysis to minimize the problem of multicollinearity (Chan 2004). The collinearity statistics showed an average variance inflation factor (VIF) of 2·43 (1·65–3·07) and tolerance of 0·33 (0·25–0·47) for the first model. The second model had an average VIF of 1·28 (1·07–3·48) and tolerance of 0·55 (0·25–0·83), while the third model had average VIF and tolerance of 1·78 (1·06–3·54) and 0·64 (0·25–0·86) respectively. This suggests that multicollinearity was not a problem for the three models (Allison 1999). Bivariate and multivariate analyses were performed for participants (n = 318) without pressure ulcers in the initial assessment. The statistical significance value was set at $P < 0{\cdot}05$.

Results

Participant demographics

Of the 346 participants, 129 (37·28%) were male and 217 (62·72%) female. They were aged between 65 and 100 years, with a mean of 82·37 (SD = 7·15).

Pressure ulcer incidence

Among the 346 participants assessed, 318 (91·91%) did not have pressure ulcers at initial assessment. In subsequent assessments, 80 participants (25·16%) of 318 developed at least one 'first' pressure ulcer (range = 1–5, mean = 2·88, SD = 2·35) after an average of nine observation days. Of these 28, 20 (71·43%) developed at least one 'new' pressure ulcer (range = 1–4, mean = 1·29, SD = 0·66) after an average observation of 7 days. Overall, 100 (28·90%) participants developed either new or first pressure ulcers (Figure 1). Stage 1 pressure ulcers were dominant (71·25%). The coccyx (41·00%) and sacrum (12·00%) were the most common areas where pressure ulcers developed (Table 1).

Table 1 Location and stages of pressure ulcers first identified at the 4-week assessments (n = 346)

	New pressure ulcers, frequency (%)	First pressure ulcers, frequency (%)	Total pressure ulcers, frequency (%)
Stage			
I	14 (70·00)	57 (71·25)	71 (71·00)
II	5 (25·00)	18 (22·50)	23 (23·00)
III		3 (3·75)	3 (3·00)
Non-stage		2 (2·50)	3 (3·00)
Location			
Right ear	1 (5·00)		1 (1·00)
Left ear	2 (10·00)	1 (1·25)	3 (3·00)
Head back		1 (1·25)	1 (1·00)
Right elbow		1 (1·25)	1 (1·00)
Left elbow		2 (2·50)	2 (2·00)
Right hand		7 (8·75)	7 (7·00)
Left hand		1 (1·25)	1 (1·00)
Right wrist		2 (2·50)	2 (2·00)
Left wrist		2 (2·50)	2 (2·00)
Right femur		1 (1·25)	1 (1·00)
Right knee		1 (1·25)	1 (1·00)
Left knee		2 (2·50)	2 (2·00)
Left iliac		1 (1·25)	1 (1·00)
Coccyx	3 (15·00)	38 (47·50)	41 (41·00)
Sacrum	8 (40·00)	4 (5·00)	12 (12·00)
Right ankle	4 (20·00)	5 (6·25)	9 (9·00)
Left ankle		7 (8·75)	7 (7·00)
Right foot		1 (1·25)	1 (1·00)
Other	2 (10·00)	3 (3·75)	5 (5·00)

Bivariate analysis of factors and pressure ulcer development

Gender, age, smoking, use of sedatives, some comorbidities (heart failure, hypertension, chronic obstructive pulmonary disease, arthritis, Parkinson disease and diabetes mellitus), moisture, body build for height, skin type and nutrition were not statistically significant. Of the clinical factors, mode of feeding (χ^2 = 29·21, d.f. = 3, $P \leq 0{\cdot}001$) was statistically significantly associated with pressure ulcer development. Among the health status factors, activities of daily living ($t = -7{\cdot}92$, $P \leq 0{\cdot}001$), severity of impairment ($t = 4{\cdot}66$, $P \leq 0{\cdot}001$), cognitive function ($t = 6{\cdot}44$, $P \leq 0{\cdot}001$) and some comorbidities including pneumonia (χ^2 = 9·90, d.f. = 1, P = 0·003), gastric ulcer (χ^2 = 5·76, P = 0·025), renal failure (χ^2 = 6·32, d.f. = 1, P = 0·018), stroke (χ^2 = 9·12, d.f. = 1, P = 0·003) and dementia (χ^2 = 14·03, d.f. = 1, $P \leq 0{\cdot}001$) were statistically significant. Of seven pressure ulcer risk factors, problems of sensory perception (χ^2 = 10·02, d.f. = 3, P = 0·018), activity (χ^2 = 49·85, d.f. = 3, $P \leq 0{\cdot}001$), mobility (χ^2 = 35·74, d.f. = 3, $P \leq 0{\cdot}001$), and friction and shear (χ^2 = 34·42, d.f. = 2, $P \leq 0{\cdot}001$) were statistically significant in residents with pressure ulcers. Pressure ulcers developed in residents living in nursing homes with no nurses on duty (χ^2 = 0·074, d.f. = 1, P = 0·038) and a greater number of nursing assistants per 100 residents (t = 2·74, P = 0·006; Table 2).

Multivariate analysis of factors and pressure ulcer development

The discrimination and calibration statistics indicated that the data fitted all three models. Among these models, the

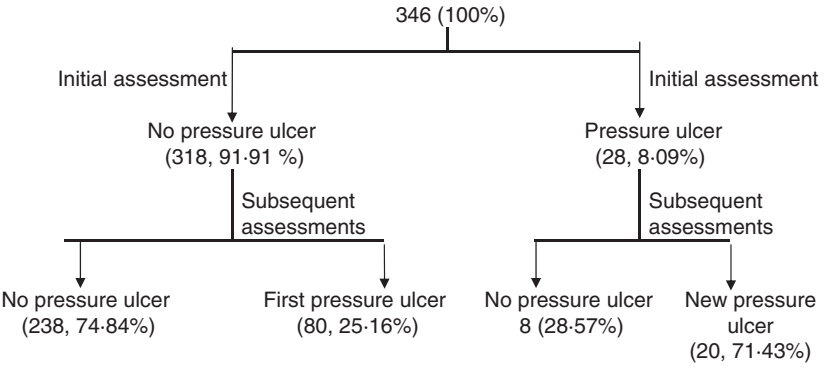

Figure 1 Pressure ulcer incidence.

Table 2 Bivariate analysis of factors and pressure ulcer development (n = 318)

	Total participants, n (%)	Participants with pressure ulcers, n (%)	Participants without pressure ulcers, n (%)	t value	P value	χ^2 (d.f.)	P value
Demographic factors							
Age (years)							
Mean (SD)	82·35 (7·15)	82·83 (7·00)	82·19 (7·27)	0·687	0·492		
Gender							
Male	116 (36·48)	36 (31·03)	80 (68·97)			3·35 (1)	0·081*
Female	202 (36·48)	44 (21·78)	158 (78·22)				
Clinical factors							
Smoking							
Non-smoker	224 (72·03)	55 (24·55)	169 (75·45)			0·31 (2)	0·855
Ex-smoker	73 (23·47)	20 (27·40)	53 (72·60)				
Smoker	14 (4·50)	4 (28·57)	10 (71·43)				
Mode of feeding						29·21 (3)	≤0·001
Oral feeding without assistance	220 (69·18)	38 (17·27)	182 (82·73)				
Oral feeding with assistance	67 (21·07)	24 (35·82)	43 (64·18)				
Nasogastric tube feeding	29 (9·12)	17 (58·62)	12 (41·38)				
Nasogastric tube feeding supplemented with oral feeding with assistance	2 (0·63)	1 (50·00)	1 (50·00)				
Use of sedatives							
Yes	51 (16·78)	16 (31·37)	35 (68·63)			1·05 (1)	0·298*
No	253 (83·22)	62 (24·51)	191 (75·49)				
Health status factors							
Activity of daily living mean (SD)	17·04 (5·72)	13·03 (5·39)	18·39 (5·18)	−7·92	≤0·001		
Severity of impairment mean (SD)	0·28 (0·16)	0·35 (0·17)	0·26 (0·15)	4·66	≤0·001		
Cognitive function mean (SD)	13·11 (5·67)	16·48 (6·05)	12·00 (5·08)	6·44	≤0·001		
Comorbidities							
Heart failure							
Yes	39 (12·42)	11 (28·21)	28 (71·79)			0·17 (1)	0·696*
No	275 (87·58)	69 (25·09)	206 (74·91)				
Hypertension							
Yes	203 (64·86)	53 (26·11)	150 (73·89)			0·12 (1)	0·788*
No	110 (35·14)	27 (24·55)	83 (75·45)				
Pneumonia							
Yes	51 (16·29)	22 (43·14)	29 (56·86)			9·90 (1)	0·003*
No	262 (83·71)	58 (22·14)	204 (77·86)				
Chronic obstructive pulmonary disease							
Yes	25 (7·99)	4 (16·00)	21 (84·00)			1·31 (1)	0·341*
No	288 (92·01)	76 (26·39)	212 (73·61)				
Gastric ulcer							
Yes	45 (14·38)	18 (40·00)	27 (60·00)			5·76 (1)	0·025*
No	268 (85·62)	62 (23·13)	206 (76·87)				
Renal failure							
Yes	26 (8·31)	12 (46·15)	14 (53·85)			6·32 (1)	0·018*
No	287 (91·69)	68 (23·69)	219 (76·31)				
Arthritis							
Yes	38 (12·14)	13 (34·21)	25 (65·79)			1·70 (1)	0·233*
No	275 (87·86)	67 (24·36)	208 (75·64)				
Stroke							
Yes	120 (38·34)	42 (35·00)	78 (65·00)			9·12 (1)	0·003*
No	193 (61·66)	38 (19·69)	155 (80·31)				
Parkinson disease							
Yes	23 (7·35)	7 (30·43)	16 (69·57)			0·31 (1)	0·621*
No	290 (92·65)	73 (25·17)	217 (74·83)				

Table 2 (*Continued*)

	Total participants, *n* (%)	Participants with pressure ulcers, *n* (%)	Participants without pressure ulcers, *n* (%)	*t* value	*P* value	χ^2 (d.f.)	*P* value
Dementia							
Yes	121 (38·66)	45 (37·19)	76 (62·81)			14·03 (1)	≤0·001
No	192 (61·34)	35 (18·23)	157 (81·77)				
Diabetes mellitus							
Yes	115 (36·74)	28 (24·35)	87 (75·65)			0·14 (1)	0·788*
No	198 (63·26)	52 (26·26)	146 (73·74)				
Human resources factors							
Nurses working in the homes							
No	170 (53·46)	50 (29·41)	120 (70·59)			0·074 (1)	0·038*
Yes	148 (46·54)	30 (20·27)	118 (79·73)				
No. nursing assistants per 100 residents mean (SD)	14·85 (9·85)	17·44 (11·03)	14·81 (9·87)	2·74	0·006		
Pressure ulcer risk factors, *n* (%)							
Sensory perception							
Completely limited	9 (2·83)	3 (33·33)	6 (66·67)			10·02 (3)	0·018
Very limited	36 (11·32)	16 (44·44)	20 (55·56)				
Slightly limited	48 (15·09)	14 (29·17)	34 (70·83)				
No impairment	225 (70·75)	47 (20·89)	178 (79·11)				
Moisture							
Constantly moist	25 (7·86)	8 (32·00)	17 (68·00)			3·98 (3)	0·26
Often moist	22 (6·92)	3 (13·64)	19 (86·36)				
Occasionally moist	63 (19·81)	12 (19·05)	51 (80·95)				
Rarely moist	208 (65·41)	57 (27·40)	151 (72·60)				
Activity							
Bedfast	46 (14·47)	27 (58·70)	19 (41·30)			49·85 (3)	≤0·001
Chairfast	78 (24·53)	28 (35·90)	50 (64·10)				
Walks occasionally	106 (33·33)	18 (16·98)	88 (83·02)				
Walks frequently	88 (27·67)	7 (7·95)	81 (92·05)				
Mobility							
Completely immobile	18 (5·66)	8 (44·44)	10 (55·56)			35·74 (3)	≤0·001
Very limited	68 (21·38)	33 (48·53)	35 (51·47)				
Slightly limited	116 (36·48)	26 (22·41)	90 (77·59)				
No limitation	116 (36·48)	13 (11·21)	103 (88·79)				
Friction and shear							
Problem	41 (12·89)	19 (46·34)	22 (53·66)			34·42 (2)	≤0·001
Potential	105 (33·02)	40 (38·10)	65 (61·90)				
No apparent problem	172 (54·09)	21 (12·21)	151 (87·79)				
Body build for height							
Obese	11 (3·46)	3 (27·27)	8 (72·73)			5·53 (3)	0·137
Emaciated	16 (5·03)	5 (31·25)	11 (68·75)				
Above/below average	124 (38·99)	39 (31·45)	85 (68·55)				
Average	167 (52·52)	33 (19·76)	134 (80·24)				
Skin type							
Oedematous	26 (8·18)	10 (38·46)	16 (61·54)			2·74 (3)	0·434
Tissue paper	11 (3·46)	3 (27·27)	8 (72·73)				
Dry	70 (22·01)	17 (24·29)	53 (75·71)				
Normal	211 (66·35)	50 (23·70)	161 (76·30)				
Nutrition							
Very poor	0 (0·00)	0 (0·00)	0 (0·00)			2·24 (3)	0·326
Probably inadequate	34 (10·69)	12 (35·29)	22 (64·71)				
Adequate	182 (57·23)	45 (24·73)	137 (75·27)				
Excellent	102 (32·08)	23 (22·55)	79 (77·45)				

*Fisher's exact test.

third had the highest value (0·839, $P \leq 0·001$) for the area under the receiver operating characteristic (ROC) curve and the highest sensitivity (95%) and specificity (60%) (Table 3). Table 4 shows the three models and statistically significant factors. Being bedfast and chairfast were statistically significant in all three models. In the first model, being bedfast [odds ratio (OR) = 16·45, $P \leq 0·001$] or chairfast (OR = 6·48, $P \leq 0·001$) was statistically significant after adjustment for pressure ulcer risk factors. Controlling for clinical characteristics, health status and human resources factors in addition to pressure ulcer risk factors increased the odd ratios of being bedfast (OR = 24·64, $P \leq 0·001$) or chairfast (OR = 8·23, $P \leq 0·001$) in the third model. Being bedfast (OR = 24·64, $P \leq 001$) or chairfast (OR = 8·23, $P \leq 0·001$), having renal failure (OR = 3·66, $P = 0·014$) or stroke (OR = 2·33, $P = 0·009$), nurses working in the nursing home (OR = 0·26, $P \leq 0·001$) and number of nursing assistants per 100 residents (OR = 1·09, $P \leq 0·001$) had interactive effects on pressure ulcer development.

Discussion

Our study had several limitations. First, as the officers in charge of the study homes were fully informed of the study purpose, they might have exerted more influence and control over the standard of care provided by the nursing assistants to protect the reputations of the nursing homes. This may have resulted in lower pressure ulcer incidences. Therefore, in future studies records of preventive nursing interventions performed are needed to enable researchers to explore such situations. Second, a total of 136 residents (47 refused to participate in the study and 89 were hospitalized or left the homes) who met the selection criteria did not join the study, and this might also have affected the pressure ulcer incidence. Third, the study was conducted in four private for-profit nursing homes, thus limiting its generalizability. Our findings are applicable to older residents in nursing home settings with similar characteristics to those of our study homes, which run services for profit, have residents from the lower socio-economic classes, and have few or no nurses.

Pressure ulcer incidence

Compared with reported pressure ulcer incidences of between 11·9% and 39·4% (Vap & Dunaye 2000, Baumgarten *et al.* 2004, Santos & Souza 2007) in nursing homes and 2·2–29% in long-term care facilities (Cuddigan *et al.* 2001, Horn *et al.* 2004), the incidence rate (25·16%) of 'first' pressure ulcers in our study was on the high side.

Given the fact that 67·8% of residents in 138 private for-profit nursing homes receive the Comprehensive Social Security Allowance in Hong Kong (Liberal Party 1995), it is likely that many residents of these nursing homes are unable to afford and thus are not paying the usual high service fees. To survive, such nursing homes have to make a profit while also charging low service fees to attract residents. To reduce costs, they therefore employ nursing assistants, many of whom are poorly educated and inadequately trained, to

Table 3 Discrimination and calibration statistics for the three models (n = 318)

	Area under receiver operating characteristic curve			Hosmer and Lemeshow test		
	Area	95% CI	*P* value	χ^2 value	d.f.	*P* value
Model 1	0·747	0·684–0·805	≤0·001	0·008	2	1·000
Model 2	0·794	0·733–0·854	≤0·001	8·766	6	0·187
Model 3	0·838	0·782–0·897	≤0·001	11·053	8	0·199

CI, confidence interval.

Table 4 Three models with significant factors (n = 318)

	Model 1				Model 2				Model 3			
	Wald	OR	95% CI	*P* value	Wald	OR	95% CI	*P* value	Wald	OR	95% CI	*P* value
Activity												
Bedfast	32·02	16·45	6·23–43·37	≤0·001	31·54	18·51	6·68–51·24	≤0·001	29·87	24·64	7·81–77·73	≤0·001
Chairfast	16·56	6·48	2·63–15·94	≤0·001	15·90	6·67	2·62–16·95	≤0·001	15·29	8·23	2·86–23·66	≤0·001
Pneumonia	–	–	–	–	3·33	1·93	0·95–3·90	0·045	NS	NS	NS	NS
Renal failure	–	–	–	–	6·22	3·32	1·29–8·51	0·013	5·98	3·66	1·29–10·38	0·014
Stroke	–	–	–	–	NS	NS	NS	NS	6·92	2·33	1·24–4·39	0·009
Nurses working in the homes	–	–	–	–	–	–	–	–	14·03	0·26	0·13–0·53	≤0·001
No. nursing assistants per 100 residents	–	–	–	–	–	–	–	–	23·74	1·09	1·05–1·12	≤0·001

OR, odds ratio; CI, confidence interval; NS, non-statistically significant; –, not entered into multivariate analysis.

provide most of the care. As a result, a high risk for pressure ulcers may occur. An earlier study showed that for-profit nursing homes had a higher pressure ulcer incidence than those not operating for profit (Baumgarten *et al.* 2004). The incidence of 'new' pressure ulcers (71·43%) in our study was much higher than that of 'first' pressure ulcers (25·16%).

In general, residents with pressure ulcers are more frail and dependent in nursing homes. Evidence has shown that they have poor mobility (Bergquist 2001), skin condition (Chan *et al.* 2009) and nutritional status (Reed *et al.* 2003), decreased ability in activities of daily living (Capon *et al.* 2007) and pain perception (Ash 2002), and problems of friction and shear force (Bergquist 2003), all of which likely increase the chance of developing pressure ulcers. More preventive efforts should thus be implemented for residents with existing or potential pressure ulcers.

Pressure ulcer risk factors

Our study revealed that the predictive power of the model is increased when more study factors are entered into the analysis. The third model, with the factors of clinical characteristics, health status, pressure ulcer risk and human resources controlled, had a greater area under the ROC curve than the other two models, indicating that it was more accurate in distinguishing nursing home residents with and without pressure ulcer development. This implies a need for multi-dimensional assessment of residents for better pressure ulcer prediction and prevention.

Our first model showed that, of the risk factors from the Braden and MBS, poor activity (being bedfast or chairfast) was statistically significantly associated with greater likelihood of developing pressure ulcers. This statistical significance was maintained in the second and third models, indicating that bedfast or chairfast residents had a higher probability of developing pressure ulcers than ambulatory residents. Baumgarten *et al.* (2004) reported a similar finding. In addition, two previous studies have identified risk factors for pressure ulcer development as poor mobility, decreased serum level and impaired self-positioning among bedfast older people in a hospital (Mino *et al.* 2001) and long periods of being bedfast, male gender and Lower Ankle-Brachial Index (Okuwa *et al.* 2006) among bedfast people in a long-term facility. Evidence-based interventions to minimize these risk factors are thus suggested for better prevention of pressure ulcers among older nursing home residents who are confined to bed or chair. These include, for example, using pressure-reducing and support surfaces to reduce or relieve pressure (Reddy *et al.* 2006), turning residents on specialized foam mattresses every 4 hours (Defloor *et al.* 2005), placing residents in a supine and semi-fowler's 30° position in which both the head and the foot end of the bed are raised 30°, or in a 30° lateral lying position (Defloor 2000), and giving residents nutritional supplements to minimize the risk of malnutrition and weight loss (Horn *et al.* 2004). Future studies are needed to investigate the risk factors affecting pressure ulcer development in bedfast or chairfast older residents in nursing homes.

Clinical factors

No clinical factors studied were statistically significant predictors of pressure ulcer occurrence in our study. This may be sample-specific and requires investigation in future studies.

Health status factors

Among all the health status factors studied, renal failure and stroke were statistically significantly associated with pressure ulcer development in our third model. Pressure ulcers are more likely to occur in older nursing home residents with renal failure and/or previous stroke than in those without these, as found in previous studies (Margous *et al.* 2003). Depending on the severity levels of renal failure or stroke, these residents decrease activity levels and mobility and increase friction and shear force. Diminished sensory perception, difficulty in eating and being at risk of malnutrition are also likely in stroke survivors (Westergren *et al.* 2001). All these are possible reasons for an increased likelihood of developing pressure ulcers, and preventive efforts should address them to reduce pressure ulcer risk.

Human resource factors

In our study, older residents in nursing homes where there were no nurses but more nursing assistants were more likely to develop pressure ulcers than those in nursing homes where there were nurses and fewer nursing assistants. This finding supports the importance of nurses working in nursing homes in terms of pressure ulcer prevention, in accordance with previous reports (Horn *et al.* 2004, 2005, Capon *et al.* 2007). Nurses in nursing homes act as supervisors to supervise and monitor the care given by nursing assistants to residents. To decrease service costs, many private for-profit nursing homes, such as those in Hong Kong, are replacing nurses with nursing assistants, who have a lower education level and have received less training than nurses. If there are no nurses in nursing homes, having more nursing assistants is less likely to contribute to good quality of care because of the inadequate

What is already known about this topic

- Older residents in nursing homes are especially vulnerable to pressure ulcer development.
- Most pressure ulcers are potentially preventable if reliable prediction and appropriate nursing interventions are performed in a timely manner.
- Demographic, clinical, health status, pressure ulcer risk and human resource factors are statistically associated with the pressure ulcer development of older people in various healthcare settings.

What this paper adds

- Pressure ulcer prediction is more powerful when the clinical characteristics and health status of residents and the human resources of nursing homes are taken into account in addition to residents' pressure ulcer risk.
- Bedfast and chairfast older residents are more likely to develop pressure ulcers than ambulatory patients when three different combinations of four categories of factors (clinical, health status, pressure ulcer risk and human resources factors) are controlled.
- Bedfast or chairfast residents with renal failure and/or stroke and living in nursing homes where there are no nurses but more nursing assistants are more likely to develop pressure ulcers.

Implications for practice and/or policy

- Multi-dimensional assessment of nursing home residents should be performed for reliable prediction of pressure ulcer risk.
- Evidence-based interventions to minimize the occurrence of pressure, friction and shear force, decreased pain perception and poor nutrition among bedfast and chairfast residents should be adopted.
- An appropriate ratio of nurses to nursing assistants in nursing home settings should be considered for better pressure ulcer prevention.

professional guidance and supervision they receive from a dwindling number of nurses. In this regard, an appropriate ratio of nurses and nursing assistants in nursing home settings should be considered for better pressure ulcer prevention.

Conclusion

Our study has confirmed that nursing homes are particularly critical settings for developing pressure ulcers, and demonstrates the higher risk for pressure ulcer development among bedfast or chairfast residents in these homes, especially those with comorbidities (renal failure and/or stroke) and those living in nursing homes where there are no nurses but only nursing assistants. For better pressure ulcer prevention, we suggest the use of multi-dimensional assessments of residents, adoption of evidence-based interventions to minimize the possible problems of pressure caused by body weight exerted on skin and subcutaneous tissue, malnutrition, friction and shear force, and decreased pain perception among bedfast and chairfast residents, and an appropriate ratio of nurses and nursing assistants. We also recommend further research with older residents in various types of nursing homes for three purposes: validating our findings, identifying factors for pressure ulcer development among residents confined to beds or chairs, and developing a multi-dimensional pressure ulcer prediction tool for nursing home settings.

Funding

The study was funded by the Dean's fund, Faculty of Health and Social Sciences, The Hong Kong Polytechnic University.

Conflict of interest

No conflict of interest has been declared by the authors.

Author contributions

EWYK, SMCP, GHA were responsible for the study conception and design; GHA performed the data collection; EWYK and GHA performed the data analysis; EWYK and SMCP made critical revisions to the paper for important intellectual content; SSML provided technical support and SMCP supervised the study.

Acknowledgement

The authors thank Dr Anthony Wong for his advice on data analysis.

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